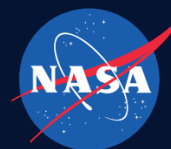


Characterize Human Forward Contamination Project

Center Innovation Fund: JSC CIF (Also Includes JSC IRAD) Program | Space Technology Mission Directorate (STMD)

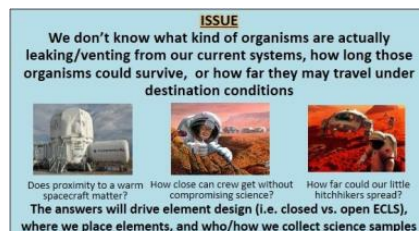


ABSTRACT

Let's face it: wherever we go, we will inevitably carry along the little critters that live in and on us. Conventional wisdom has long held that it's unlikely those critters could survive the space environment, but in 2007 microscopic animals called Tardigrades survived exposure to space and in 2008 Cyanobacteria lived for 548 days outside the International Space Station (ISS). But what about the organisms we might reasonably expect a crewed spacecraft to leak or vent? Do we even know what they are? How long might our tiny hitch-hikers survive in close proximity to a warm spacecraft that periodically leaks/vents water or oxygen—and how might they mutate with long-duration exposure? Unlike the Mars rovers that we cleaned once and sent on their way, crew members will provide a constantly regenerating contaminant source. Are we prepared to certify that we can meet forward contamination protocols as we search for life at new destinations?

This project has four technical objectives:

1. **TEST:** Develop a test plan to leverage existing equipment (i.e. ISS) to characterize the kinds of organisms we can reasonably expect pressurized, crewed volumes to vent or leak overboard; **as part of testing, we'll need to develop an Extravehicular Activity (EVA)-compatible tool that can withstand the pressure and temperature extremes of space, as well as collect, separate, and store multiple samples.**
2. **ANALYZE:** Develop an analysis plan to study those organisms in relevant destination environments, including spacecraft-induced conditions.
3. **MODEL:** Develop a modeling plan to model organism transport mechanisms in relevant destination environments.
4. **SHARE:** Develop a plan to disseminate findings and integrate recommendations into exploration requirements & operations.

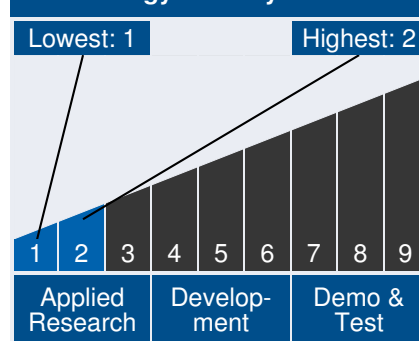


Issue Statement

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Technology Maturity



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In short, we propose a system engineering approach to roadmap the necessary experiments, analysis, and modeling up front--rather than try to knit together disparate chunks of data into a sensible conclusion after the fact.

ANTICIPATED BENEFITS

To NASA funded missions:

Understanding where and how organisms can escape from pressurized volumes--and whether they survive under destination conditions--will help inform several Advanced Exploration System projects, including Extravehicular Activity Technology, Deep Space Habitat, and Advanced Life Support.

To NASA unfunded & planned missions:

Preventing--or at least understanding--human forward contamination will help engineers meet planetary protection protocols as they design hardware, but will also help the science community understand how close exploration crews can get without compromising science objectives. These insights will help shape architectures and operations for future exploration missions.

To the commercial space industry:

Test, analysis, and modeling derived from this project will be of interest to both government and commercial exploration ventures.

To the nation:

This project will help the U.S. meet international planetary protection agreements.

DETAILED DESCRIPTION

The focus of this road-mapping effort will be "what can we do now with what we have?" For example, the micro-organisms



2 Success Stories

Management Team

Project Manager:

- Michelle Rucker

Principal Investigator:

- Michelle Rucker

Co-Investigators:

- Mary Sue Bell
- Douglas Botkin
- Brian Glass
- Anthony Hood
- James Johnson
- Stanley Love
- Mark Lupisella
- Mark Ott
- Duane Pierson
- Margaret Race
- Andrew Schuerger
- Kasthuri Venkateswaran

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inside the ISS are well-characterized...but no one has ever swabbed an ISS external vent to find out what (if anything) has managed to get outside. We can swab ISS vents now, without having to develop new hardware. If we take a sample and find nothing, that's good news!—it means that our environmental control and life support (ECLS) systems may already meet forward contamination requirements. If we do find organisms outside the ISS, it will be interesting to see how they compare with what we typically find inside. Are they the same? Or have they mutated? What corrective measures can we take to prevent external contamination? Once we know what manages to escape a typical spaceship, we can expose it to various destination environments and see how it's likely to behave. We can go one step further, and test those organisms in a spacecraft-induced environment to understand whether proximity to a warm, venting spaceship makes a difference; that will tell us how far away we must land from a sensitive area to mitigate forward contamination. We can also bring the modeling community into play and overlay destination weather models onto bacterial growth models to estimate how far microbes could be transported by, say, a small dust storm on Mars.

Another opportunity might be to take a sample from an Exploration Extravehicular Activity (EVA) Suit during development testing and follow similar steps as outlined above: what organisms come out of a suit vent or leak from the suit? How close can EVA crew be to a sensitive site without compromising the science objectives? Data would tell us what modifications might be required to the suit *now*—early in the development phase—and avoid an expensive redesign later.

This project expects to produce a comprehensive test, analysis and modeling plan. To support future testing, we'll also need to develop a specialized tool to collect swab samples. On Earth, this type of sampling is typically done with a simple swab, much like a sterile Q-tip®, that is wiped across a surface and stored in

Technology Areas

- Human Health, Life Support & Habitation Systems (TA06)
- Environmental Control & Life Support Systems & Habitation Systems (TA06.1)
- Extravehicular Activity Systems (TA06.2)
- Human Exploration Destination Systems (TA07)

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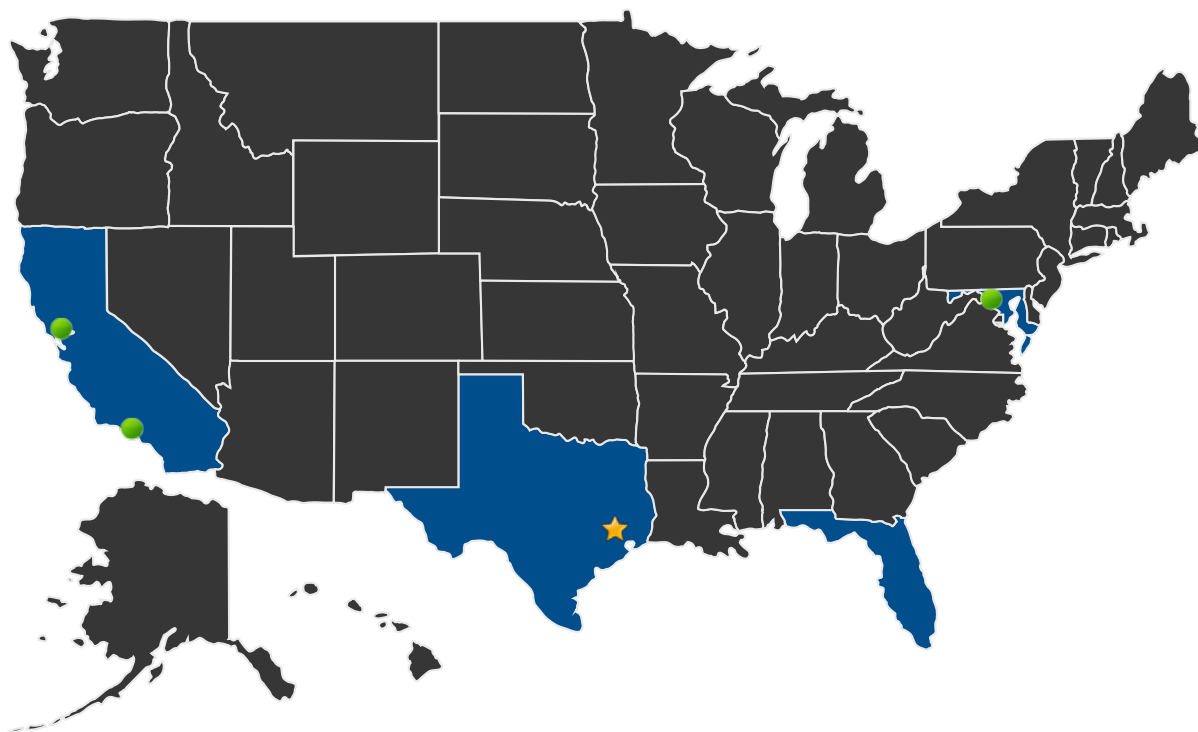
a sterile vial. But handling a small swab and vial while wearing spacesuit gloves is difficult and the swab itself will have to withstand extreme temperature swings combined with near vacuum pressures that can cause plastics to become brittle. What's more, keeping track of multiple samples--and preventing cross-contamination between--is even more challenging in microgravity, where items will float away if not restrained. In line with the project's "what can we do now with what we have?" theme, the team plans to modify a tool that was originally developed for Space Shuttle tile repairs. Retro-fitting commercially available swabs onto the EVA Brush Kit, and modifying the EVA Tool Caddy to accept commercially available sterile containers, will result in a low-cost, EVA-compatible Swab Kit that can support ground tests of development hardware in the near term, as well as flight tests of ISS external hardware later. Funded through the Johnson Space Center's 2015 Innovation Charge Account, the project will develop tool certification requirements, conduct glovebox proof of concept testing, and deliver a prototype tool suitable for use in upcoming space suit development testing.

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U.S. LOCATIONS WORKING ON THIS PROJECT



■ U.S. States With Work

★ **Lead Center:**
Johnson Space Center

● **Supporting Centers:**

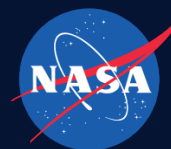
- Ames Research Center
- Goddard Space Flight Center
- Jet Propulsion Laboratory

Other Organizations Performing Work:

- SETI Institute (Mountain View, CA)
- The University of Florida

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LATEST SUCCESS STORY

NASA Planetary Protection Officer Endorsement

-----Original Message-----

From: Conley, Cassie (HQ-DA000)

Sent: Tuesday, April 07, 2015 10:27 AM

To: Rucker, Michelle A. (JSC-XM111)

Cc: Crusan, Jason (HQ-CQ000); Guidi, John (HQ-CQ000); Stansbery, Eileen K. (JSC-XA111); Ward, Brenda L. (JSC-XM111)

Subject: ISS microbial sampling IRD funding application

Greetings, Michelle --

I understand that you are pursuing the development of a microbial sampling system for EVAs on the ISS and possible other future applications -- this sounds like a very relevant capability for planetary protection.

One of the key technical challenges the human exploration of Mars is the ability to quantify effectively the microbial contamination released from spacecraft, and other human support systems, as an aide in developing mitigations for the forward contamination of Mars.

Evaluating microbial contamination associated with EVA activities on the ISS will provide a better understanding of existing contamination release from human support systems, which is a necessary first step in making improvements to current capabilities.

In the long-term, the development of microbial sampling systems will be crucial for monitoring contamination release during Mars surface operations. Monitoring and mitigation of human-associated contamination is critical to maximize the scientific return possible with the human exploration of Mars.

Your work focuses on key concerns of the Office of Planetary Protection in supporting NASA's obligations to ensure US compliance with Article IX of the UN Outer Space Treaty, and the guiding principles for human exploration as established by COSPAR. I strongly endorse your work in this area as a cross-cutting collaboration with the Planetary Protection community, Science Mission Directorate, and Human Exploration and Operations Directorate.

Best wishes for the success of your proposal,

-- Cassie

Characterize Human Forward Contamination Project

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Dr. Catharine A. Conley

Planetary Protection Officer

Science Mission Directorate

NASA Headquarters

Washington, DC 20546

ph. 202-358-3912

fax 202-358-3513

<http://planetaryprotection.nasa.gov>

PROJECT LIBRARY

News Stories

- Beer microbes Live 553 Days Outside ISS
 - (<http://www.bbc.co.uk/news/science-environment-11039206>)
- Creature Survives Naked in Space
 - (<http://www.space.com/5817-creature-survives-naked-space.html>)
- Space station research shows that hardy little space travelers could colonize Mars
 - (http://www.nasa.gov/sites/default/files/files/Fall_2014.pdf)

Presentations

- Workshop on Planetary Protection Knowledge Gaps for Human Extraterrestrial Missions
 - (<http://www.hou.usra.edu/meetings/ppw2015/pdf/1002.pdf>)

Success Stories

- NASA Planetary Protection Officer Endorsement
- "People's Choice" Honorable Mention - awarded to Michelle Rucker for "EVA Swab Tool Prototype Development"

Characterize Human Forward Contamination Project

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IMAGE GALLERY



Modifying the EVA Brush Kit handle to accept a commercially available sterile swab will result in a cost-effective EVA-compatible swab tool



Integrated Systems Engineering Approach

Forward Contamination Project Overview



Tardigrade in Moss, Image Credit & Copyright: Nicole Ottawa & Oliver Meckes / Eye of Science / Science Source Images



Andy Weir, author of "The Martian," was among the panelists that selected this project as runner-up for the "People's Choice Award"

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DETAILS FOR TECHNOLOGY 1

Technology Title

Advanced Extravehicular Activity (EVA) Spacesuits

Technology Description

This technology is categorized as a hardware assembly for wearable applications

Advanced Extravehicular Activity (EVA) spacesuits that can protect the occupant from the environment *and* protect the environment from the occupant will become more important as humans begin exploring destinations that may have the potential to support life.

Capabilities Provided

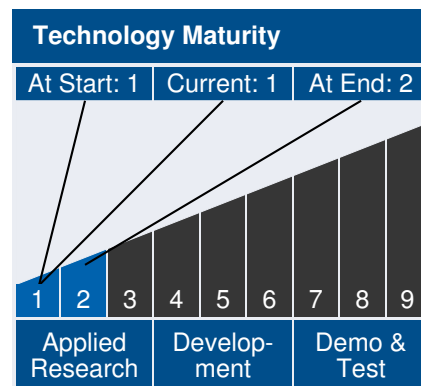
The first step is to understand the mechanisms and risks involved in potentially releasing human contamination from our spacesuits. This will inform future suit hardware and operational procedure designs.

Potential Applications

Applications include exploration EVA suits intended for destinations that may support life.

Performance Metrics

Metric	Unit	Quantity
Ability of System to prevent contamination release	percent	TBD
Ability of System to mitigate effects of contamination	percent	TBD



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DETAILS FOR TECHNOLOGY 2

Technology Title

Advanced Life Support

Technology Description

This technology is categorized as a hardware subsystem for manned spaceflight

The results of this project will help inform advanced life support technology development for exploration missions.

Capabilities Provided

This project will help characterize the types of organisms that are typically vented or leaked from current spacecraft environmental control and life support systems--and provide insight into how to prevent it or mitigate the effects.

Potential Applications

Potential applications for this technology encompass all pressurized crew compartments used at exploration destinations--everything from space suits to habitats or pressurized Mars surface rovers.

Performance Metrics

Metric	Unit	Quantity
System ability to prevent contamination release	percent	TBD

Technology Maturity

